Space Weather Technical Forecast

Issued on Tuesday, 28 February 2023 at 01:21 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: G1/G2 Minor to Moderate storms possible day 1 (28th), however CME effects easing. Chance of M-flares, with slight chance of X-flares, primarily from AR3234.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Low, with several C-class flares observed, the largest a C4.5 from sunspot region AR3234 Fki/Beta-Gamma-Delta. This is the largest of the six sunspot regions on the visible disc, and has been increasing in complexity, with increasing penumbra observed around its delta containing trailer, along with further flux emergence evident near to the south of its large leader spot. The other regions are all smaller and simpler, and either stable or showing signs of decay. There are signs of a new, potentially active, sunspot region rotating onto the northeast limb. No Earth-directed CMEs have been observed.

S**olar Wind / Geomagnetic Activity:** Solar winds have been strongly enhanced due to a couple of CME arrivals. The first from 24 Feb, arrived 26/1843 UTC, continued to influence solar winds at the start of this period with speeds 600-700 km/s. The second from 25 Feb, arrived 27/1016 UTC, resulting in speeds climbing further to be Strong to Very Strong at 700-850 km/s. The density of the wind was at or below average throughout. The total IMF was largely Moderate at 10-15nT, but became Strong for a time with the second CME arrival, peaking 21nT at 27/1025 UTC. This has since eased to near 8nT. The north-south component Bz, was predominately negative (southward). This included a period between 27/0500-27/1130 UTC where Bz largely persisted between -10nT to -20nT, with the southward peak at 27/1031 UTC due to the 2nd CME arrival. This was followed by Bz largely ranging between 0nT and -10nT with only brief spells of positive (northward) values. Phi angle has been predominantly negative (towards the Sun), but with a slow rotation through positive (towards the Sun) observed 27/1400-1900 UTC. Geomagnetic activity has been persistently at G1/Minor Storm to G3/Strong Storm levels (Kp5-7). Peak activity occurred at 27/0600-0900 UTC, which has been reassessed as being at the G3/Strong Storm level.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) as measured at GOES-16 remained below the S1 level on a declining trend, having fallen from 31ppcc to under 1 ppcc. The high energy electron flux (greater than 2 MeV) has been at background with the associated 24 hour fluence well below the Active level. This reached 2.38e6 integrated pfu at 28/0000UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Low or Moderate activity is expected through the next four days with a chance of isolated M-flares. This is predominately from AR3234 in the northwest, or from any new region rotating onto the visible disc from over the northeast horizon. This region also brings a slight chance of X-flares.

Solar Wind / Geomagnetic Activity: Ongoing CME influence is expected to only gradually recede on day 1 and 2 (28th and 1st) with no further CME arrivals currently expected. Solar winds will likely ease from their current Strong levels to be slightly elevated by the end of day 2.

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There is a low chance of a further slight enhancement following later in the period, from a small northern hemisphere coronal hole. Ongoing G1-G2/Minor to Moderate geomagnetic storming, with a slight chance of G3/Strong storms is expected at first. This easing through day 1 and 2, to become Quiet to Active, with a chance of G1/Minor Storms. Then mainly Quiet with Unsettled intervals day 3 (2nd) onward. There is a slight chance of a further enhancement later day 3 or day 4 (2nd or 3rd) from any connection to the northern coronal hole. This bringing isolated Active intervals.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 2MeV) is below the S1/Minor storm level with only a slight chance of rising above due to any significant flares that occur, primarily from AR3234 in the northwest. High energy electron flux (greater than 2MeV) is expected to rise through day 1 and day 2 (28th and 1st) in response to the recent CME enhancement, as the current Strong solar winds ease, likely reaching Moderate to High, perhaps persistently High, values day 2. The associated 24 fluence is also expected to rise in response, with a chance of reaching Active levels day 2 onward.

Figure 1a: L1 Observed Solar winds

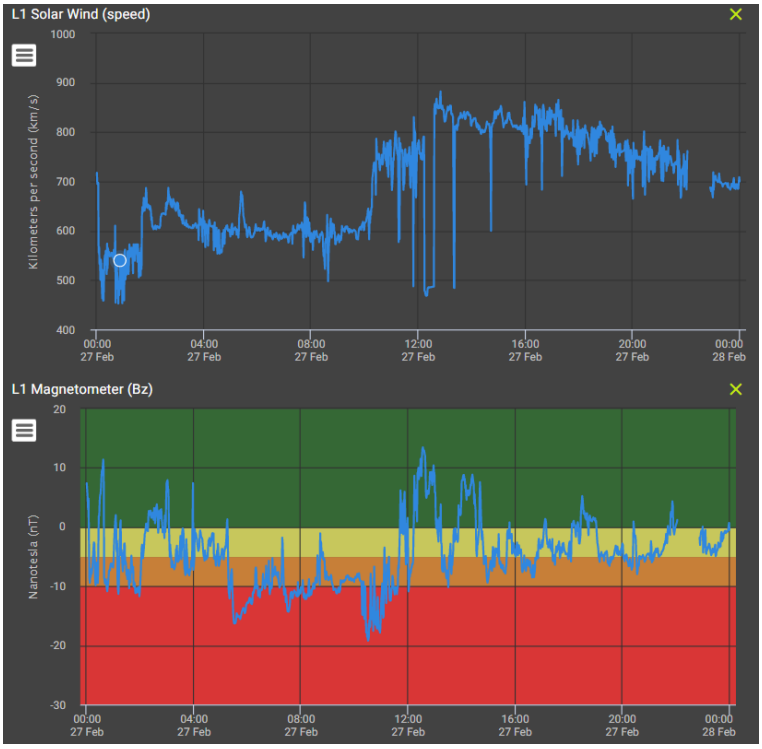

Figure 1b: BGS Estimated Kp

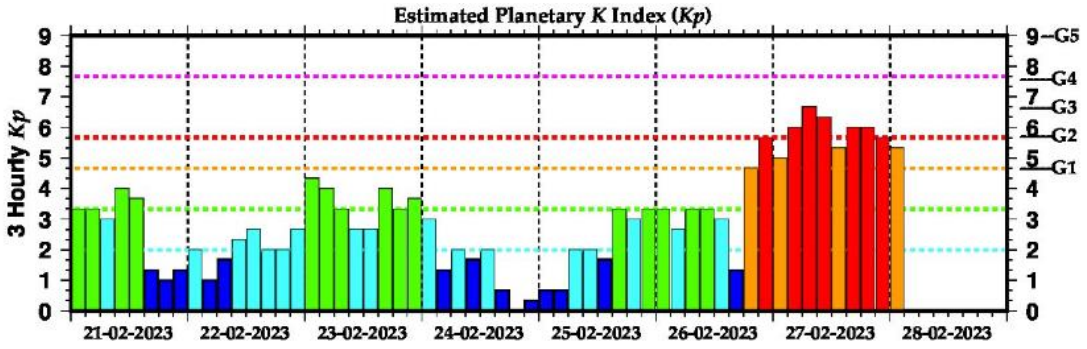

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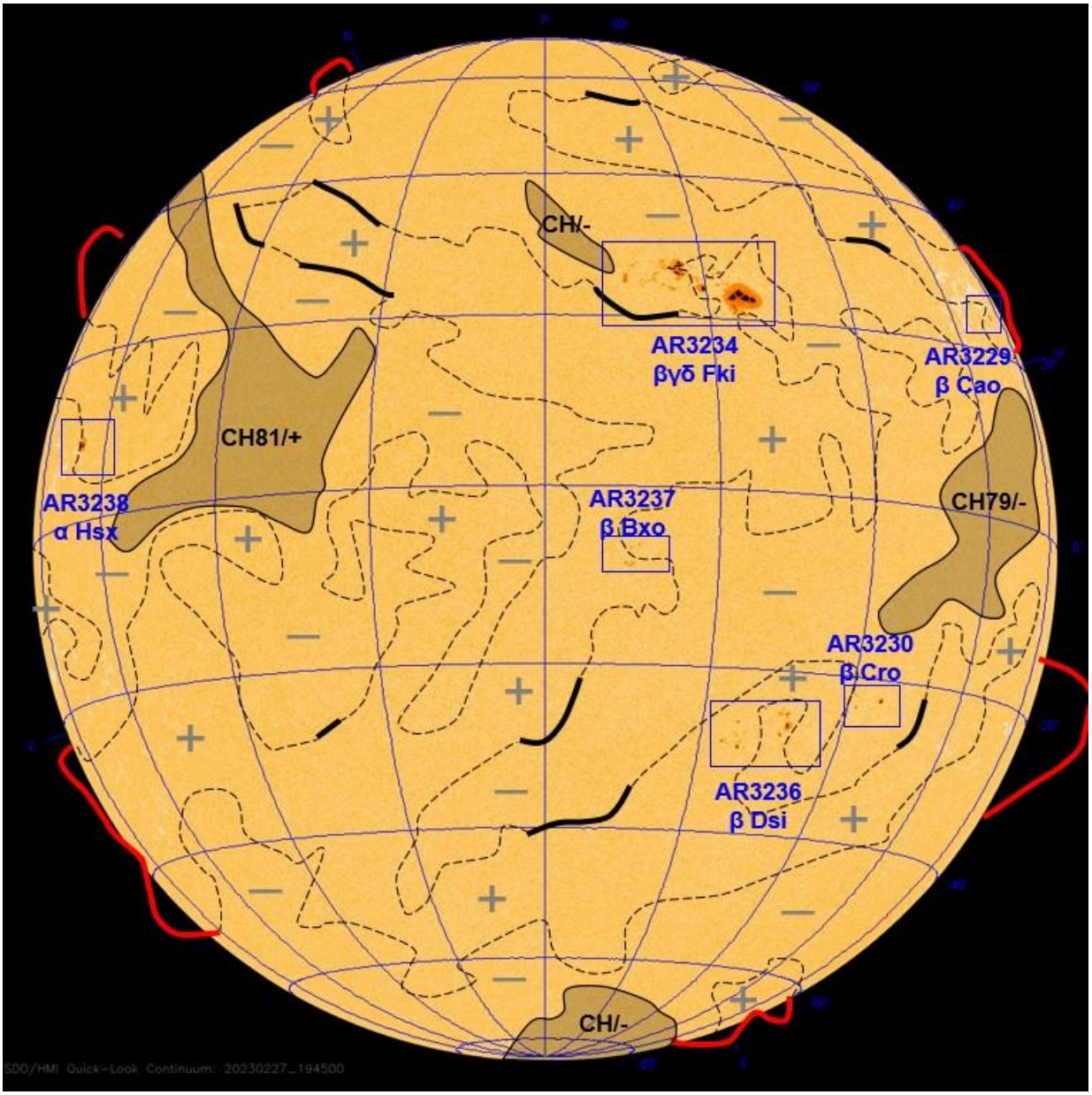
Figure 1c. Solar Analysis Valid 27/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

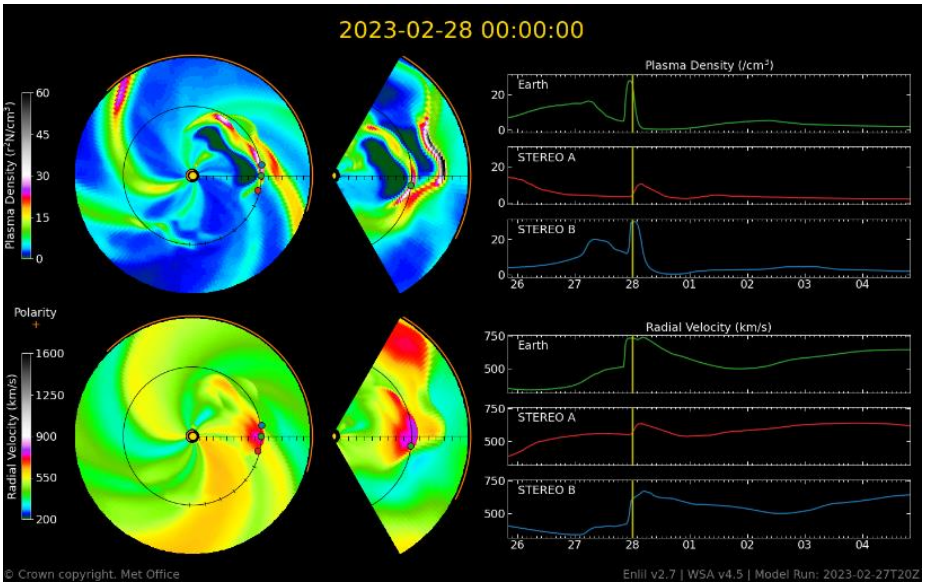
There are no further CMEs currently expected to arrive at Earth.

Two CMEs have arrived in quick succession leading to Strong solar winds and elevated geomagnetic activity, peaking at G3 Strong Storm on the 27th. The ongoing combined influence of these CMEs is expected to continue through day 1 (28th), but with a gradual and erratic weakening trend. Solar winds are expected to slowly ease from around 700km/s towards slightly elevated levels of around 400-500 km/s by the end of day 2 (1st). A further enhancement is then indicated by Enlil from day 3 (2nd), however this is low confidence as the only potential source region is a small coronal hole in the north-centre disc that is unlikely to result in the enhancement indicated.

Geomagnetic activity is expected to be at G1-G2 Minor to Moderate Storm levels at first, with an ongoing slight, but decreasing chance of rising to G3/Strong storms. These easing through day 1 and 2, to become Quiet to Active, with a chance of G1/Minor Storms. Then mainly Quiet with Unsettled intervals day 3 onward. There is a slight chance of a further enhancement later day 3 or day 4 (2nd or 3rd) from any connection to the northern coronal hole. This bringing isolated Active intervals with a slight chance of G1/Minor Storms.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	**G1 to G2**	Yes	95	30	10	10
Strong	**G3**	Yes	20	1	1	1
Severe	**G4**	No	1	1	1	1
Extreme	**G5**	No	1	1	1	1

Figure 2: Enlil showing solar winds gradually easing.



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Radio Blackouts - X-Ray Flares:

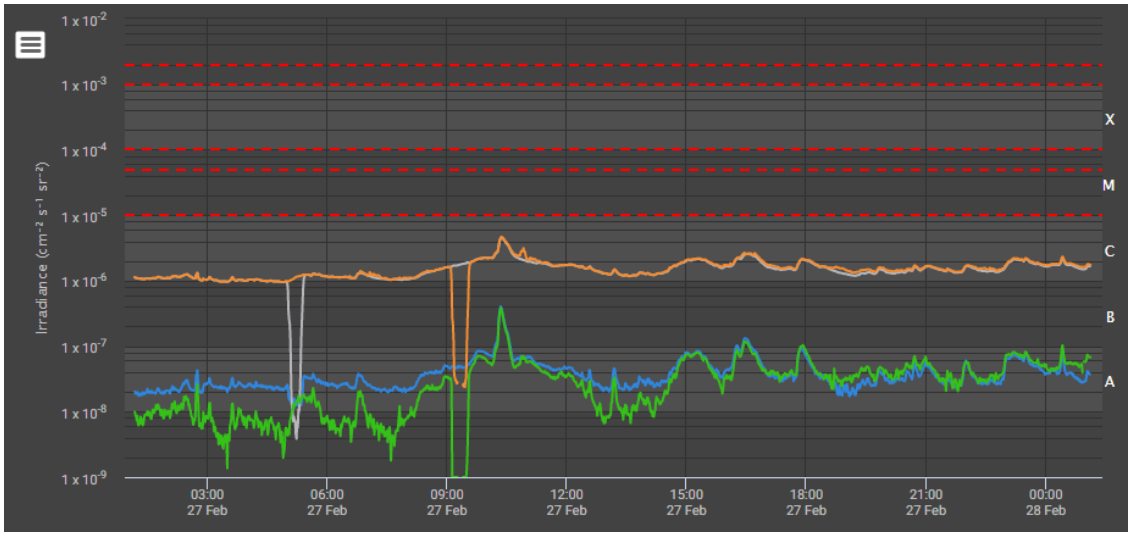
Activity is forecast to be Low to Moderate, with an ongoing chance of M-flares. There is a slight chance of X-flares, primarily from AR3234 Fki/Beta-Gamma-Delta in the northwest disc.

This region has shown some increasing levels of complexity in the last 24 hours, with penumbral growth occurring around its delta containing trailer spot, along with some small flux emergence to the south of its large leader spot. The density of magnetic looping also appears to be increasing on SDO-aia imagery, with the overall total flux of the region on a slow upward trend.

There are a total of six numbered regions on the disc, however the other regions are all much smaller and simpler, and generally either stable or showing signs of decay. This includes AR3229 Cao/Beta, now approaching the northwest limb, and AR3236 Dsi/Beta in the southwest. Some magnetic looping is visible on the northeast limb, however, showing the potential for a further region to rotate onto the disc. This is likely ex-AR3213 which was a moderately active when previously Earth-facing, being the source of 18 M-flares.

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	R1-R2 M Class	No	60	60	50	50
Very Active	R3 to R5 X Class	No	20	20	15	10

Figure 3: GOES-16/17 X-ray Flux



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Solar Radiation Storms - (High Energy Protons):

High energy (greater than 10MeV) proton flux, as observed by GOES16 has been declining through the 27th, and is expected to gradually fall towards background. AR3234 is a large northwestern disc sunspot, and has the potential to produce further significant flaring. This, alongside any other lower risk flare activity from the other regions on the disc brings slight chance of flux rates climbing again and reaching the S1 Minor Radiation storm threshold.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	10	10	10	10
Very Active	**≥ S3 ***	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)

Figure 4a: GOES-16 >10 MeV >50MeV and >100 MeV Proton Flux for the last 3 days.

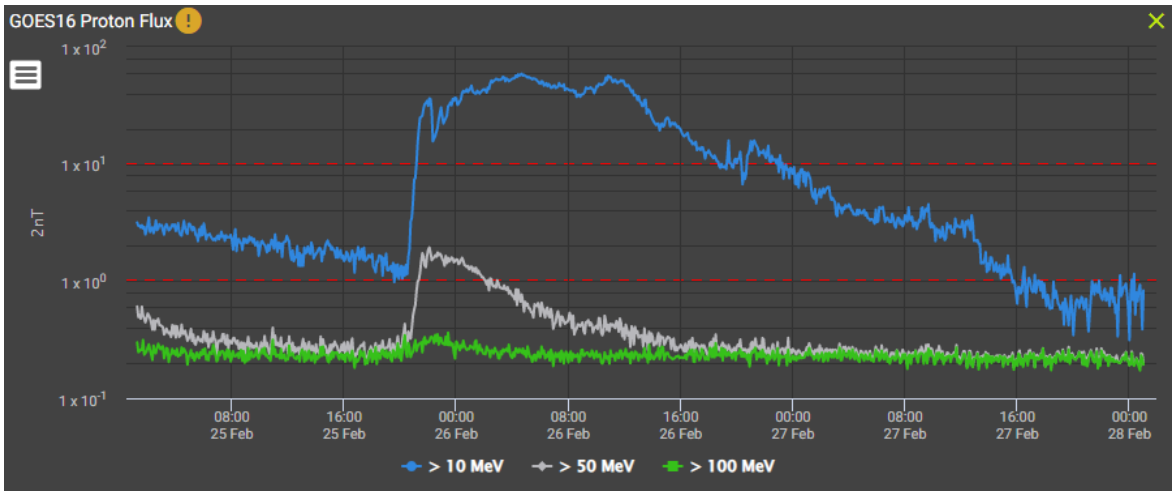
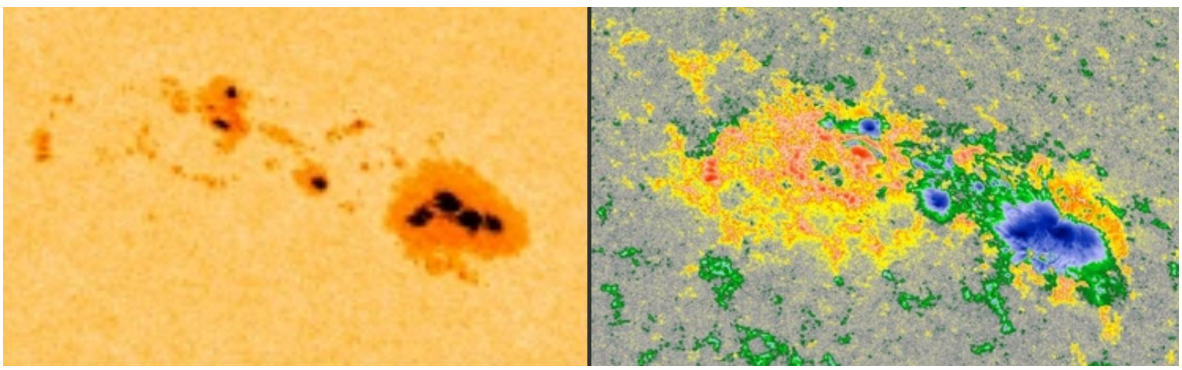


Figure 4b: SDO hmi-intensitygram and magnetogram of AR3234 in the NW.



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High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) observed at GOES16 has generally been at Background, with the Van Allen Belts compressed inward due to the ongoing Strong solar winds from the pair of CME arrivals, and the subsequent increase in solar winds pressure. These CME enhancements have likely resulted in CME counts increasing at some lower or middle Earth orbits and as the influence of these features subsides these increased counts have the potential to expand back to GEO. This will likely bring Moderate to High (greater than 1000 pfu) observed flux, with a chance of more persistently High flux becoming established through day 2 and into day 3 (1st).

The associated 24 hour fluence is forecast to be at background at first, but rising as solar winds ease later day 1 and through day 2 (28th and 1st). This will give a chance of Active fluence by the end of day 2. This is supported by REFM, which is likely giving good guidance, as no further CME arrivals or other significant enhancements are indicated.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	30	60	60	50
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	5	10	10

Figure 5: GOES-16 >2 MeV Electron Flux and Fluence with REFM

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